FLORIDA HURRICANES

By RICHARD W. GRAY

[Weather Bureau, Miami, Fla.]

During the 45-year period ending with 1930, 46 tropical cyclones either moved inland over Florida, or passed near enough to cause damaging winds in the coastal regions of the State. Of the 46 storms, 37 were of known hurricane intensity, while nine were less than hurricane intensity, or doubtful as to hurricane intensity. Table 1 shows that these storms have been fairly well distributed throughout the 45-year period, although a greater number occurred during the 5-year period, 1924–1928, than during any other period of similar length. The greatest number of consecutive years without tropical storms was two.

Although there is an average of one tropical storm a year for Florida as a whole, the average for any given part of the State is greatly less than this; and there is a marked difference in the number of storms that have occurred in the different parts of the State. Charles L. Mitchell (1) has shown that the average interval between tropical storms of hurricane intensity on the east coast of Florida, for each hundred-mile section of coast line, is 20 years, while the average interval between storms on the west Florida coast, for the same unit of coast line, is 13.9 years. The shorter interval on the west coast is due to the relatively great number of storms that have occurred between Cedar Keys, Fla., and Mobile, Ala. Only five tropical storms of hurricane intensity in the last 45 years have passed inland over the west coast of the peninsula between Fort Myers and Cedar Keys. Tampa is located in this section of the coastal region, and it has been more nearly exempt from hurricanes than any other coast city in southern Florida.

TABLE 1.—*Frequency of tropical cyclones by years*

Year	Of known hurricane intensity	Doubtful as to hurricane intensity	Total	Year	Of known hurricane intensity	Doubtful as to hurricane intensity	Total
1886	0	0	0	1911	1	0	1
1887	1	0	1	1912	1	0	1
1888	3	0	3	1913	0	0	0
1889	0	1	1	1914	0	0	0
1890	0	0	0	1915	1	0	1
1891	1	2	3	1916	1	1	2
1892	0	0	0	1917	1	0	1
1893	0	2	2	1918	0	0	0
1894	2	0	2	1919	1	0	1
1895	2	0	2	1920	0	0	0
1896	2	0	2	1921	1	0	1
1897	0	1	1	1922	0	0	0
1898	0	1	1	1923	0	0	0
1899	1	0	1	1924	3	0	3
1900	0	0	0	1925	1	0	1
1901	1	0	1	1926	3	0	3
1902	1	0	1	1927	0	0	0
1903	1	0	1	1928	3	0	3
1904	0	0	0	1929	1	0	1
1905	0	0		1930	0	0	0
1906	2	1	3	Total	37	9	46
1907	0	0	0				
1908	0	0	0				
1909	1	0	1				
1910	1	0	1				

Key West, on account of its exposed location in the Florida Straits, and Pensacola, on account of its exposed position to western Caribbean storms, have experienced more hurricanes than any other cities in the State. Key West has been in or near the paths of storms originating in both the Atlantic Ocean and the western Caribbean Sea, while all storms, but one, that passed inland over the west coast of the peninsula had their origin in western Caribbean waters. Several storms have recurved over western Cuba and struck the south coast, but all storms reaching the east coast from the Atlantic moved north of Cuba and through the Bahamas.

The northwestern Florida coast is especially exposed to the western Caribbean storms, and it has suffered from several hurricanes that moved through the Florida Straits out of the eastern Caribbean, or that crossed the Florida Peninsula and redeveloped great intensity after passing into the Gulf of Mexico. In this connection it should be said that all storms crossing the peninsula reach the opposite coast from which they entered with greatly decreased intensity. A notable example of a hurricane crossing the peninsula from the east and redeveloping great intensity over the Gulf was the Miami hurricane of September 18, 1926, which passed near Pensacola two days later, causing a wind velocity of 92 miles per hour. (Corrected to 3-cup scale.)

Contrary to popular belief, more hurricanes have occurred in Florida in October than in any other month, this in spite of the anomalous fact that no hurricane has passed inland over the east coast of Florida during October in the last 51 years. (1) All October storms have either struck the west or extreme south coasts, or have recurved to the northeastward off the lower east coast. The decided tendency for tropical cyclones to develop over the western Caribbean Sea near the end of the hurricane season is shown by the fact that, of 21 Florida storms that had their origin in the western Caribbean in the last 45 years, 12 occurred in October and two in November. One of these was the famous "loop" hurricane of October, 1910, that twice swept over Key West and Habana. (2).

The most belated tropical cyclone of record to reach the coast of the United States developed over the western Caribbean and moved northeastward through the Yucatan Channel to the extreme lower west coast of Florida, where it passed inland on November 30, 1925. It passed off the upper east coast of Florida on December 1. This storm was attended by winds of hurricane force on the extreme lower west coast and by excessive rains throughout the peninsula. A remarkable 24-hour rainfall of 15.10 inches occurred at Miami in connection with this storm.

The frequency of tropical cyclones by months for Florida is shown in Table 2. This table is based on the 45-year record ending with 1930.

TABLE 2.—*Frequency of tropical cyclones by months*

	June	July	Aug.	Sept.	Oct.	Nov.	Total
Of known hurricane intensity	2	3	7	13	11	1	37
Doubtful as to hurricane intensity	3	0	0	0	5	1	9
Total	5	3	7	13	16	2	46

A study of the chart of hurricane paths shows that tropical cyclones are most likely to occur on the east coast of Florida during the months of August and September, and on the west coast during October. The chances of a hurricane reaching the Florida coast in any given year are about one in four for the east coast and one in two for the west coast. It should be said, however, that these storms are much more likely to occur on the lower east coast, extreme lower west coast, and the northwest coast. The upper east coast section, in which Jacksonville is located, and the middle west coast section, in which Tampa and St. Petersburg are located, have been relatively free from hurricanes, and the chances of a hurricane occurring in those sections in any given year are very slight. Since the center of a hurricane, as a rule, must pass within 50 miles of a place to cause winds of hurricane force, the chances of hurricane winds occurring at any given place in any given year are considerably less than is indicated by the chart of hurricane paths. The chances of hurricane winds in any year for several of the important cities of the State are roughly indicated in Table 3.

TABLE 3.—*Chances of winds of hurricane force in any given year*

City	Chances	City	Chances
Jacksonville	1 in 50	Fort Myers	1 in 20
West Palm Beach	1 in 20	Tampa	1 in 30
Miami	1 in 20	Pensacola	1 in 10
Key West	1 in 10		

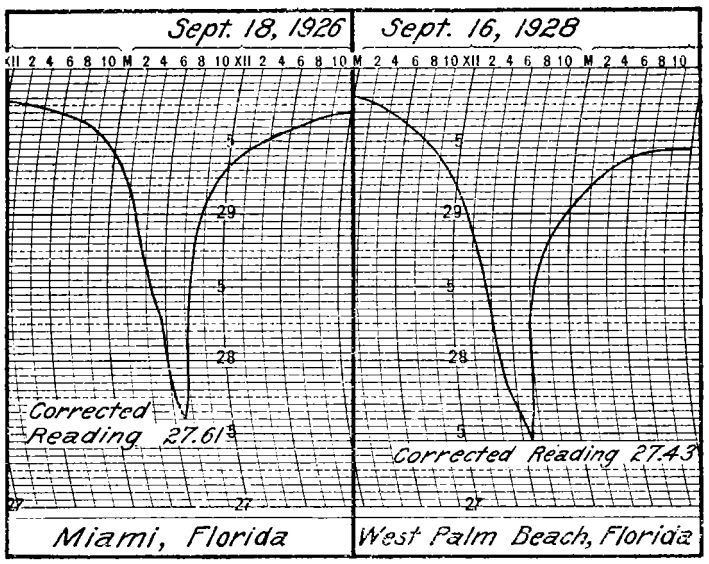
The occurrence of tornadoes in the northeast quadrant of a hurricane area was an interesting phenomenon observed in connection with the Florida hurricanes of September 10, 1919 (**3**), and September 28, 1929 (**4**). Both of these storms passed through the Florida Straits, and, when located off the extreme lower southwest coast, caused tornadoes along the lower east coast. In the case of the second storm, several tornadoes occurred from Miami northward to Stuart. These tornadoes all moved from the southeast to the northwest with the hurricane winds prevailing at the time, and the indications were that they developed over the ocean as waterspouts. Their paths extended only a few miles inland.

Of all the hurricanes that reached the Florida coast in the last 51 years, only eight can be classed as "great," both as to intensity and diameter (**1**). Several storms not so classed, however, were attended by destructive winds and loss of life. The "great" Florida hurricanes of the last 51 years were as follows:

June, 1886: Apalachicola-Tallahassee section.
July, 1916: Mobile-Pensacola section.
August, 1880: West Palm Beach-Lake Okeechobee section.
September, 1919: Key West section.
September, 1926: Miami-Lake Okeechobee-Pensacola sections.
September, 1928: West Palm Beach-Okechobee section.
October, 1910: Key West-Fort Myers section.
October, 1916: Mobile-Pensacola section.

The lowest sea-level barometer readings of record for the United States occurred in connection with the great Miami and West Palm Beach hurricanes of September 18, 1926, and of September 16, 1928. (See fig. 1.) While the barometer fell to 27.43 inches in the West Palm Beach hurricane, as compared with 27.61 inches in the Miami hurricane, it was evident from an inspection of the storm areas that a higher wind velocity occurred in the Miami storm. The trees left standing in the Miami area, even in the densest jungles, were completely defoliated, while many trees in the Palm Beach area, after the 1928 storm, were only partly defoliated. Apparently, the gradient in the West Palm Beach storm, which previously had caused a wind velocity of 160 miles per hour at San Juan, Puerto Rico, decreased before the disturbance reached the Florida coast. The diameter of the vortex of the Miami hurricane was 13 miles, while that of the West Palm Beach hurricane was approximately 25 miles. The highest recorded wind velocity for the United States, 138 miles per hour, by 3-cup anemometer registration, occurred at Miami Beach during the Miami hurricane (**5**). The much greater loss of life attending the West Palm Beach hurricane was not caused by the direct force of the wind, but by the flood waters from Lake Okeechobee.

A thorough inspection of the storm areas in the Miami and West Palm Beach hurricanes, which rank with the greatest of record in so far as wind velocity and loss of life and property are concerned, clearly indicates that hurricanes of major intensity do not cause serious structural damage to property constructed buildings. This statement does not apply to buildings near an ocean beach, where foundations may be undermined or the beach badly eroded by storm tides. Several substantial houses



near the ocean at Miami Beach were undermined and collapsed in the hurricane of September 18, 1926, but substantial buildings only one block from the ocean escaped serious structural damage. Practically all buildings were damaged by water, resulting from broken windows and doors, or from damaged roofs. In Miami there were several frame residences, with shingle roofs, which were erected when the city was first laid out, in 1896. These houses escaped, not only structural damage, but serious water damage, while many hundreds of concrete-block houses of flimsy construction were demolished. The same conditions were observed at Palm Beach, West Palm Beach, and Lake Worth, which were directly in the path of the September 16, 1928, hurricane. Office buildings of the better type, ranging in height from 10 to 20 stories, were damaged principally by water. There were a number of substantial residences that were seriously damaged by débris from other buildings or by falling trees, but, with these exceptions, the writer observed no substantially-constructed buildings in which the occupants were not safe during the entire duration of the

Miami and West Palm Beach hurricanes. In Key West, there are a considerable number of frame buildings that have withstood all the hurricanes of the last 50 years at that place without serious damage. One frame structure on the Government reservation has safely passed through all the Key West hurricanes since 1846.

Observations of the storm areas of the severe hurricanes on the east coast of Florida in 1926, 1928, and 1929 warrant the following statement.

If a building is properly constructed, including the proper type of roof and roofing material, and is securely anchored to the proper kind of foundation, it will not sustain serious structural damage in a hurricane of major intensity. If, in addition to the proper construction, all windows, doors, and vents are protected by storm shutters, the building should withstand strong hurricane winds with practically no damage. Such a building can be constructed at only a moderate increase of cost above that for the usual type of construction, and the saving in storm insurance will repay the extra cost in a few years time.

Grateful acknowledgment is made to Mr. B. K. Durst, who prepared two of the tables used in this paper.

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(NOTE.—No tropical storms of consequence passed over Florida during 1931 or 1932.—Editor).

LAKE OKEECHOBEE AND SAFETY FROM TROPICAL STORMS

By A. J. MITCHELL

[Weather Bureau Office, Jacksonville, Fla.]

SYNOPSIS

This paper describes Lake Okeechobee as to area, depth, configuration, drainage area, and other features, particularly with reference to the hurricane disasters of 1926 and 1928.

Lake Okeechobee is in the south-central portion of the Florida peninsula; it is between 30 and 40 miles in diameter. The surface of the lake is between 700 and 800 square miles; its depth varies from a maximum of 15 feet to only a few inches at the outer circumference, especially on the south and west shores where the water is shallow. The configuration of the lake is nearly round, and its drainage area comprises 5,300 square miles. The Everglades, an area about 90 miles long and 40 miles wide, compose an area of 4,500 square miles; they are just to the south of the lake and over which shore (south) the flood waters of Lake Okeechobee found their exit to a large extent. It was to drain these glades that inspired the first efforts of Gov. N. B. Broward in seeking a platform in race for governor. Broward made the race on "Draining the Everglades," which platform carried him into the State's executive chair, and later to the very door of the United States Senate, but a cruel fate decreed that he should not enter; he died before he took his seat.

I have, thus, termed the Lake Okeechobee and Everglades project: An industrial baby, born of a political exigency.

Progress now being made to offset the dreadful incidents which have attended tropical storms in the Okeechobee region during the last few years should prove reassuring to many who have property and other interests in the Everglades district. The State of Florida and the Federal Government are constructing levees on and around the lake to the end that disasters such as those that attended the hurricanes of 1926 and 1928 shall not recur.

There has been so much apprehension in some circles regarding the safety of life and property on Lake Okeechobee, Fla., since the occurrence of the hurricanes of 1926 and 1928 that it seems wise to give publicity to the activities of the Federal Government and the State of Florida on the lake with the assurance that when the projects now under way shall be fait accompli there need be little concern with respect to the security of all interests on Lake Okeechobee and adjacent waters, regardless of the possible severity of tropical disturbances which, however, are by no means of annual occurrence.

Lake Okeechobee is between 30 and 40 miles in diameter, being the largest body of fresh water within the continental interior of the United States, exclusive of Lake Michigan which we do not consider as coming within the purview of this paper.

Geographically, the lake is in the south-central portion of the Florida peninsula. It is generally round, suggestive of a natural amphitheater, the depth varying from a maximum of about 15 feet to a gentle wind tide of a few inches near the outer rim of the lake, especially on the south and west shores. Latitude 26″ north and longitude 81° west bisect, so to speak, the center of the lake.

The geological history of the State indicates that Lake Okeechobee was much larger at one time, and that it fills an original depression in the floor of the sea which once covered the coastal terrace. Pleistocene and pliocene shells are seen on the spoils banks of the canals, and the shoal waters out from Moore Haven are underlain with pleistocene shells, marl, and limestone; thus giving some knowledge of the varying life phases of the peninsula, which appears to be quite ancient.

The water surface of Lake Okeechobee is between 700 and 800 square miles, and it has a drainage area, mostly to the north, comprising 5,300 square miles which represent in the aggregate the drainage areas of Taylors Creek, Fisheating Creek, and the Kissimmee River, the last named being the chief tributary, reaching to the northward 137 miles as measured by the course of the stream, but in reality less than 100 miles. The deepest water in the lake will not be more than 15 feet when the elevation of the water surface of the lake is 15 feet above mean low water at Punta Rassa on the Gulf of Mexico.

Immediately to the south of Lake Okeechobee are the Everglades, a low marshy area about 90 miles long and 40 miles wide, comprising 4,500 square miles. These lands slope toward the southern end of the Florida peninsula at the rate of 2 or 3 inches to the mile. Originally, the elevation of the Everglades bordering on the lake was 21 to 22 feet above mean low water of the Gulf of Mexico, but as a result of drainage operations the land has subsided to 17 and 19 feet above the mean low water of the Gulf. A large volume of the flood waters of the lake is or was discharged over its southern rim, and before the drainage work became effective the Everglades were covered by several feet of water. As evidence of the vagaries of lake stages its depth varying with the volume supplied by its tributaries, the deficiency in rainfall during the year 1931 has resulted in a decided contraction of the water line, and at this time one can walk dry shod about one mile nearer the lake's center; in fact, enterprising truck growers have